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--> Comment Text :
When considering the use of titanium as a shielding/packaging product (for example titanium drip pans) be aware that there are new manufacturing processes available that would allow for a much broader use of titanium versus say steel on a cost effective basis. This has significant implications in terms of better strength and corrosion resistance for the storage containers and structural supports being considered in the Yucca Mountain project. Inserted here is an article referring to this new process:

Get tough! 30 Jun 01

The titanium revolution is here, and it's going to change everything from cutlery to cars, says Steve Hill. Are you ready for a stronger, lighter, shinier world?

TITANIUM is fantastic stuff-it's lighter than steel yet strong and tough enough to survive the extremes of space or the corrosive salts and pressures of the deep ocean with hardly a blemish. In fact, just about the only drawback with the material is its price tag. Titanium is currently six times as expensive as stainless steel. But this looks set to change, with the discovery of a new way to extract titanium metal that requires little more than black sand and electricity. It's a far cry from the usual
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method, which is slow, expensive and consumes tonnes of corrosive chemicals. Best of all, the process promises to slash the price of the metal by up to three-quarters.

Put this new technology to work and titanium could infiltrate our lives in all kinds of ways. Manufacturers could replace steel, aluminium and even some plastics, creating a new generation of lightweight, high-speed ships and fuel-efficient engines. With titanium beams, cables and tie rods, engineers could stretch skyscrapers and bridges to new extremes. Cars built with titanium parts and bodies would never rust.

The new process also promises exotic titanium alloys and shape-memory metals, and we may even see entirely new materials that can't be made by conventional techniques. "This is the century of titanium," says Rod Beddows, director of British Titanium, a company set up to exploit this new technology.

Like many of the best discoveries, this one was made entirely by accident. Derek Fray, head of the department of materials science and metallurgy at Cambridge, wasn't even trying to extract titanium. Together with a couple of colleagues, he was simply attempting to purify it.

Titanium usually contains a small amount of dissolved oxygen near its surface which can weaken the material. So Fray, Tom Farthing and George Chen decided to try to remove this impurity using electrolysis. They hoped that current flowing through the titanium would drag the oxygen ions to the surface of the material where they could be removed. But the researchers noticed an unexpected side effect.

The titanium they were using had a thin layer of oxide on its surface-something which always forms when the metal is exposed to air. They noticed that during the electrolysis this oxide coating was converted back to the pure metal. The discovery seemed too good to be true, so they tried the trick on particles of solid titanium dioxide-the same stuff used to whiten paper and paint. Unbelievably, the electrolysis converted the oxide to titanium metal.

The researchers realised they had stumbled across a completely new way to extract titanium. The following year Fray sent a confidential report to Britain's Defence Evaluation and Research Agency, DERA, and visited DERA metallurgist Malcolm Ward-Close to discuss the Cambridge results. "I could hardly believe it," Ward-Close says. "I got very excited and offered to develop the technology and scale it up."

Funding for such a speculative idea was hard to come by. The project remained on hold until James Hamilton, the chairman of Bushveld Alloys, a South African titanium exploration company, visited DERA. He offered to fund a pilot plant in exchange for an exclusive licence, and the team set up British Titanium. Work on the pilot plant began soon afterwards.

A few years later and the first production trials at DERA have finished. The small plant has proved extremely successful. "It worked like a dream," says Ward-Close.

The process takes place in an electrolytic cell. The cathode is connected to a pellet of titanium dioxide powder, while the anode is made of an inert material such as carbon. The two electrodes are immersed in a bath of molten calcium chloride, which acts as the electrolyte. When the power is switched on, electrons at the cathode decompose the titanium dioxide into titanium metal and oxygen ions. The ions flow through the electrolyte to the anode, where oxygen is released as a gas.

Now British Titanium plans to build a much larger pilot plant and to move towards full commercial exploitation of the technology-now named the FFC Cambridge process after its discoverers.

Light work

Compared to the Kroll process-the method used at the moment to extract titanium from its ore-FFC is revolutionary, says Hamilton. The Kroll process converts titanium ore into titanium tetrachloride and then reacts it with liquid magnesium to produce titanium metal and magnesium chloride. It is a batch process that is expensive, labour intensive and relatively slow. "The process takes several days and produces only a few tonnes of titanium per reactor vessel," says Harvey Flower, a metallurgist at Imperial College, London. What's more, mass production is difficult with the Kroll process. All in all it has some pretty serious limitations.

On the other hand, Ward-Close estimates that the FFC process would take less than 24 hours to produce the same amount of titanium a Kroll reactor vessel produces in a week. Crucially for mass-production purposes, FFC could be a continuous process, churning out slabs of titanium from one end while the oxide is fed in at the other. It's also far less polluting than the Kroll process and incredibly reliable, says Hamilton. DERA is successfully producing kilogram batches of titanium metal time and time again.

If the process scales up to an industrial level as expected, the price of titanium should fall substantially-perhaps by as much as 75 per cent. "It will create a new demand for titanium metal," says Hamilton. In about a decade, he predicts, we could have a full-scale titanium revolution.

British Titanium believes it could eventually increase titanium usage from its current level of 60,000 tonnes up to 1 million tonnes per year. There's certainly no shortage of raw materials. Titanium is the ninth commonest ore in the Earth's crust.

So where will we see the benefits of the revolution? Well, there are all its current applications, of course-titanium is already used in the aircraft industry and for prosthetic implants such as hip replacements. Cheaper titanium would certainly expand the repertoire of materials used in these areas. Architects, too, like the stuff. Pretty soon, shimmering titanium cladding like that on the Guggenheim Museum in Bilbao could be springing up all over the place. And why not use it structurally, says Simon Cardwell, a metallurgist at London-based engineering consultants Arup. Titanium may not be as stiff as steel, but with its strength and corrosion resistance, it could help engineers design bigger and longer-lasting bridges and skyscrapers.

And then there's the motor industry. Car manufacturers have long had their eyes on titanium as a substitute for steel, but it has always been too expensive. "The car industry would like to use titanium as it is light, strong and highly corrosion resistant," says Fray. An engine containing titanium parts, for example, would be much lighter so you could expect significantly better fuel consumption than today's engines offer.

Unfortunately, it's going to be quite some time before your car's body panels are cast from titanium. The price of the material would have to fall even further if it is to replace the kinds of cheap steel currently used in car bodies. Ward-Close has a solution, however, and he found it on the beach. "We are looking at using rutile sand, which is basically black sand," he says. "The better stuff is about 96 per cent titanium dioxide." He thinks that the FFC process could turn rutile sand into a cheap and cheerful titanium alloy suitable for car body panels.

But it's in alloy production that FFC really seems to excel. It can produce alloys directly, including the most widely used one, which contains 6 per cent aluminium and 4 per cent vanadium. "The Kroll process cannot do this," Flower says.

This is a major breakthrough. Alloys are generally much more useful than pure metals because the proportions can be adjusted to give the mixture much better properties than the individual metals. And with the FFC process, alloy production is simplicity itself. "It's just like making a cake," says Ward-Close. You simply blend in the alloying additions as oxides, stick them together and bake the mixture in a kiln. This high-tech cake then forms the cathode in the FFC process, and the oxides are all converted into metal. Et voila! The perfect alloy almost every time.

Better still, the process isn't restricted to titanium. Fray has produced zirconium, niobium, iron and chromium from their oxides, and turned out many of their alloys too. He believes the process will enable them to make exotic alloys and compounds that are usually difficult-or impossible-to make. Things like shape-memory alloys, for example. These are alloys that change shape when heated or cooled in the right way. Most can be bent into any shape you want at low temperatures, but return to their original shape when heated.

Nickel-titanium is a common shape-memory alloy, but it is hard to produce because nickel and titanium have different densities. With the FFC process, says Fray, nickel-titanium would be far cheaper. They are also looking at making superconducting alloys-such as niobium-titanium-and magnetic materials, which should cost about one-tenth as much as the same materials made using conventional techniques.

With this array of exotic alloys in the pipeline, we may even see a new generation of cheap supersonic aircraft or lightweight, personal mini-helicopters. And thanks to its corrosion resistance, titanium is a natural for naval applications-Japan already has a number of small craft and racing yachts made using titanium.

In a decade or so, you may find yourself at the quayside, ready to set sail in a gleaming, lightweight titanium cruise liner. Because the metal is so light, the ship would sit high in the water as it whisks you across the ocean. If its titanium-alloy engines are efficient enough, the ship may even be able to skim over the water's surface, cutting the journey time to a fraction of what traditional steel liners can manage.

By the time all these grand designs for titanium come about, you'll probably be used to it cluttering up your house as well. "If titanium overlaps with stainless steel in price, it could take a big slice of the market," says Ward-Close. This high-tech metal could end up in lightweight saucepans, washing machines and cookers-even the kitchen sink. "How about a canteen of titanium cutlery?" Flower suggests.

Titanium may have proved itself in the aerospace industry and on missions to the ends of the Solar System, but when it finally makes it into the home, it will face its ultimate test. Could titanium toys ever be tough enough to survive the temper tantrums of a three-year-old?

Steve Hill is Editor of Materials World

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